Progress Report #2

For the project entitled:

Field Investigation of Geosynthetics Used for Subgrade Stabilization

Reporting Period: July 1 - September 30, 2008
(First Quarter of State Fiscal Year 2009)

Submitted by:

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Task 0: Project Management

Two informal meetings were held at the project site during this past quarter. During the first meeting, Jeff Jackson and Rich Jackson from the technical panel at MDT met with WTI staff on site to observe construction of the test sections. Jeff Jackson and Rich Jackson of MDT also traveled to the test site after trafficking to observe the excavation of the geosynthetics during the forensic investigations. Additionally, Kent von Maubeuge of NAUE and Barry Christopher of Christopher Consultants visited the site at various stages before construction and after trafficking to monitor progress and visually inspect the individual test sections. The project is on schedule but is not on budget. Additional funds are being sought from the Western Transportation Institute University Transportation Center.

Task 1: Design and Construction of Test Sections

- Construction: Casino Creek Concrete was the contractor that constructed the test sections. The general steps to the construction were as follows:
    - The test pit trench was excavated, graded and compacted.
    - Trench was lined with 6-mil plastic.
    - Artificial subgrade was installed using the following procedure:
        1. Condition subgrade stock pile by adding water and mixing
        2. Transport conditioned soil to trench
        3. Spread subgrade using lightweight equipment (track-mounted skid steer)
        4. Use tractor-mounted tiller to blend soil
        5. Add or remove water based on moisture level
        6. Allow soil to dry slightly on the surface
        7. Compact with vibratory roller
        8. Check strength using vane shear and moisture
        9. Repeat steps 4 through 8 if not within specification
        10. Cover with next layer to keep from drying out
    - Top of subgrade was sealed with plastic to ensure no moisture loss while instrumentation was set up.
    - Geosynthetics were installed in each test section as shown in Figure 1. Pertinent properties associated with each of the geosynthetic materials are provided in Table 1.
    - The instrumentation, which consisted of LVDTs and pore pressure gauges, was installed along with the power systems and data acquisition computers.

- Once delivered to the test site, the base course was constructed above the geosynthetics using the following procedure:
  1. Condition base course by blading and adding water.
  2. Place base course on top of the geosynthetics using lightweight equipment (track-mounted skid steer) in a single 20 cm thick lift.
  3. Grade base course from the side using a motor-grader with an extended blade.
  4. Compact the base course using a vibratory roller until it is uniform for all of the test sections.

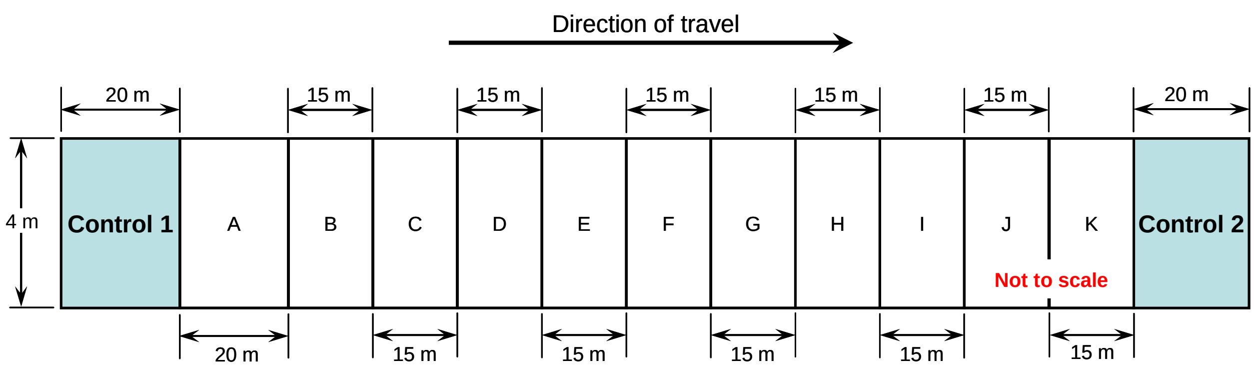

Figure 1. Layout of test sections.

Table 1. Summary of Geosynthetic Properties

Test Section	Structure	Polymer[a]	Roll Width (m)	Mass per unit area (g/m^2)	Aperture Size (mm)	Strength[c] @ 2% (kN/m)	Strength[c] @ 5% (kN/m)	Ultimate[c] Strength (kN/m)
A	biaxial welded geogrid	PP	5.00	240	44 x 40	11 [NP]	22 [NP]	30
B	vibratory-welded geogrid	PP	4.75	155	32 x 32	8 [8]	16 [16]	20 [20]
C	integrally-formed biaxial geogrid	PP	4.88	NP	25 x 33	6.0 [9.0]	11.8 [19.6]	19.2 [28.8]
D[†]	composite vibratory-welded geogrid with integrated non-woven geotextile	PP	4.75	200	32 x 32	12 [12]	24 [24]	30 [30]
				150	N/A	N/A	N/A	6 [10]
E	integrally-formed biaxial geogrid	PP	4.00	NP	25 x 33	4.1 [6.6]	8.5 [13.4]	12.4 [19.0]
F	vibratory-welded geogrid	PP	4.75	200	32 x 32	12 [12]	24 [24]	30 [30]
G	integrally-formed triaxial geogrid	PP	3.81	NP	NP	NP	NP	NP
H	PVC coated woven geogrid	PMY	4.00	308.5	25.4 x 25.4	7.3 [7.3]	13.4 [13.4]	29.2 [29.2]
I	polymer coated woven geogrid	PMY	3.66	NP	25.4 x 25.4	7.7 [8.4]	11.5 [15.2]	34.9 [56.5]
J	woven geotextile	PPY	3.81	342	0.425[b]	8.8 [8.8]	21.9 [21.9]	52.5 [47.3]
K	non-woven needle-punched geotextile	PP	4.57	NP	0.18[b]	NP	NP	912[d]

[†] Material D is a composite; the top row of values is for the grid component and the bottom row is for the non-woven textile
[a] PP = polypropylene, PMY = polyester multifilament yarn, PPY = polypropylene yarn
[b] Apparent Opening Size (AOS), ASTM D 4751
[c] Machine direction [cross-machine direction]
[d] Grab strength in Newtons

NP – information was not provided by the manufacturer; N/A – information not applicable

- <u>Test Section Setup</u>
  - Lines were painted for the truck to follow.
  - Test sections were marked and measured.
  - A topographic survey of the surface of the base was taken in the area where the rut bowl was to form as a benchmark by which to compare future deformations from trafficking.
  - Instrumentation was tested.

Task 2: Soil Testing and Instrumentation

- <u>Bottom of trench</u>: density was measured on the bottom of the excavated trench to ensure uniformity along the length of the test site. Density measurements along the trench bottom were within ±5% of one another.
- <u>Artificial Subgrade Soil</u>: moisture content, density and strength of the artificial subgrade were measured during construction to ensure uniform throughout. Density was measured on the final lift using a nuclear densometer. Shear strength was measured using a hand held vane shear device during construction, and a dynamic cone penetrometer was used to characterize the subgrade once it was completed before the base course was installed.
- <u>Base course</u>: density of the base was measured using a nuclear densometer to ensure uniformity along the length of the test site. Two passes of the vibratory roller were made on the surface of the base course.
- <u>Instrumentation</u>:
  - Pore pressure was measured 15 cm beneath the top surface of the subgrade directly under the wheel path of the truck to quantify static and dynamic pore water pressure during trafficking. The point of measurement was remotely made using a rigid plastic tube with a porous stone attached to the end to reduce the influence of having a gauge present in the subgrade. All of these components were saturated with de-aired water prior to installation.
  - Displacement measurements were made at three locations of each geosynthetic using Linear Variable Displacement Transducers (LVDTs). Lead wires were attached to the geosynthetic and run through rigid tubes back to the LVDTs mounted in sensor boxes that were rigidly mounted to the pavement. Static and dynamic displacement measurements were made in the area of the rut bowl during trafficking.
  - Data acquisition and power systems were designed, purchased and installed to collect static and dynamic measurements during

trafficking. Cables were run in PVC conduit from the data boxes associated within each test section to one of three metal cabinets which contained the data acquisition computer.

Task 3: Vehicle Loading and Data Collection

- Test Vehicle: trafficking was accomplished using a three-axle dump truck rented and driven by WTI staff. The truck was loaded to 20,860 kg (45,990 lb.) using concrete blocks. The test truck drove across the test sections at approximately 15 kph, staying on the designated path by lining the front axles up with the painted lines. Five of the thirteen test sections required repair during trafficking to facilitate continued passage of the test vehicle. This repair consisted of filling in the ruts with additional base material and generally smoothing out the driving surface.
- Data Collection:
    - Topographic survey measurements were made of the longitudinal and transverse rut profiles to monitor rut development during trafficking. These measurements were made during passes **1**, **2**, **3**, 4, **5**, 6, 7, 8, **10**, **15**, 16, 17, **25**, **30**, and **40** (bold numbers indicate passes where all unfailed test sections were surveyed). Once a test section reached an average of 10 cm of rut (as determined from the elevation measurements), no further surveys were conducted on that section.
    - Long term data was collected from all of the displacement and pore pressure sensors during trafficking.
    - High speed data (200 Hz) was collected as the test vehicle traversed the test sections.
- Forensic Investigations:
    - Post-trafficking excavations were conducted within each of the test sections to evaluate: damage to the geosynthetic, soil properties of the subgrade, and mixing of the subgrade and base materials. Areas within each test section that had experienced 10 cm of rut were chosen as the location to conduct these investigations so that comparisons of damage between the various products would be similar. The length of these excavations was 1.5 meters and extended across the entire width of the test section.
    - The base course was removed using an industrial vacuum cleaner to minimize damage to the geosynthetics. Once exposed, the geosynthetics were removed and are being stored for further analysis, including: visual damage assessment, tension tests and junction strength tests.

- The subgrade was then removed to assess soil properties at various depths along the excavated walls (10, 20, 40 and 60 cm below the interface between the subgrade and base course). Soil samples of the subgrade were also collected to determine the moisture content at these same points.
- Several samples of base course were also collected above the geosynthetic to evaluate soil mixing in each of the test sections.

Task 4: Analysis

The analysis of the rut data and the long term and high speed sensor data began this quarter. Overall and relative performance of the various test sections will be determined using all of the data collected during this project. This analysis will be completed and summarized in a draft of the final report for the project during next quarter.

Task 5: Reporting

A draft of the final report for the project will be submitted by December 31, 2008 to summarize the construction and describe the analytical results.

Budget and Schedule

Funding for this project was provided by NAUE, MDT and WTI. Table 2 summarizes the combined total budget for the project, and shows the total expenditures through September 30, 2008 for all three entities. Additional funds are currently being sought from the Western Transportation Institute University Transportation Center to finish the remaining tasks associated with the project.

Table 2. Summary of Expenditures

Budget Category	Budgeted Funds	Spent This Period	Total Spent	Total Remaining
Salaries/Wages	$47,204.00	$36,888.78	$68,294.19	($21,090.19)
Benefits	$13,813.00	$6,761.49	$16,975.02	($3,162.02)
Travel	$12,775.00	$8,090.04	$9,972.90	$2,802.10
Expendible Supplies	$27,140.00	$29,558.38	$46,488.92	($19,348.92)
Construction Contracts	$120,559.00	$65,769.63	$65,769.63	$54,789.37
Tuition	$4,000.00	$0.00	$0.00	$4,000.00
Direct Costs	$225,491.00	$147,068.32	$207,500.66	$17,990.34
Indirect Costs	$36,594.00	$29,721.61	$42,737.45	($6,143.45)
Total	**$262,085.00**	**$176,789.93**	**$250,238.11**	**$11,846.89**

A summary of the project status is shown in Figure 2. Progress associated with the project is shown as percent completeness within individual tasks. In summary, the design, construction, instrumentation, data collection, trafficking and forensic excavations are complete. The bulk of the remaining tasks include data analysis and composing the final report for the project.

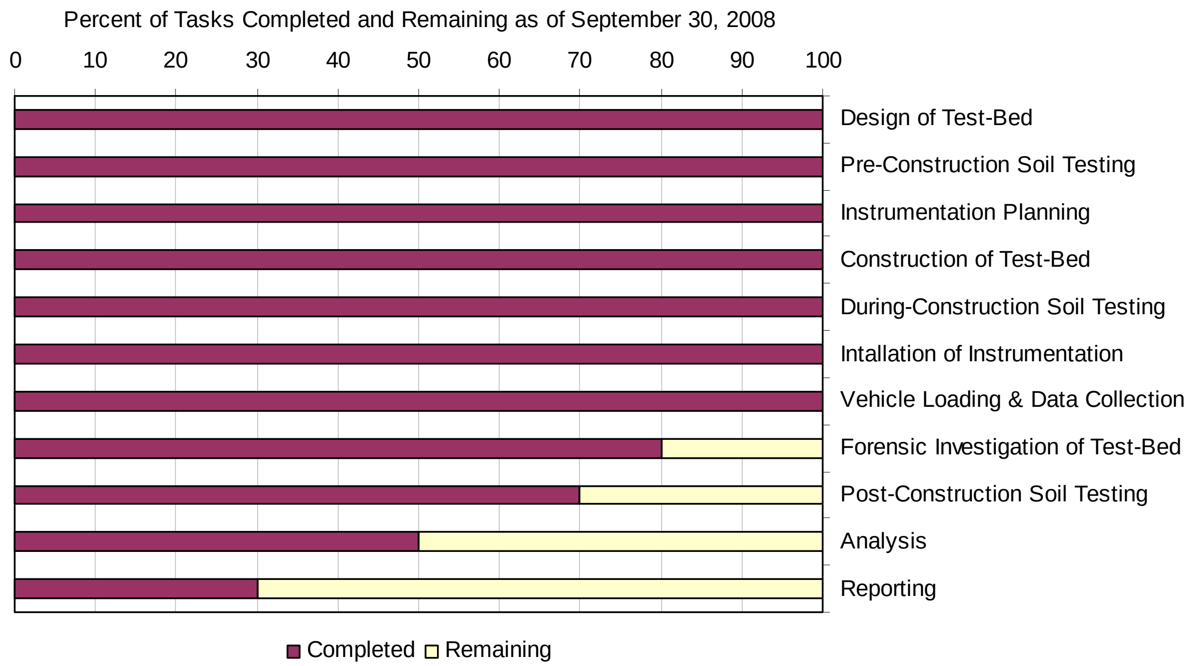

Figure 2. Project schedule